Misconceptions and Knowledge Gaps on Antibiotic Use in Primary Care – a Delphi Study in Four Sectors and Five European Countries

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Article

Misconceptions and Knowledge Gaps on Antibiotic Use in Primary Care – A Delphi Study in Four Sectors and Five European Countries

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Abstract: Background: Misconceptions and knowledge gaps about antibiotic use contribute to inappropriate antibiotic use and antimicrobial resistance. Aim: Identifying and prioritizing misconceptions and knowledge gaps about antibiotic use from a healthcare professionals' perspective. Methods: A modified Delphi study of two rounds with an expert meeting. A literature search was conducted to create statements about misconceptions and knowledge gaps about antibiotic use. These were rated by healthcare professionals from five EU countries representing general practice, out-of-hour services, nursing homes, and pharmacies. Consensus was achieved if ≥80% of the participants rated 4+ on a five-point Likert scale during the second Delphi round. Results. In total, 44 misconceptions were identified through the literature search within four themes: 1) antimicrobial resistance in general, 2) use of antibiotics in general, 3) use of antibiotics for respiratory tract infections, and 4) use of antibiotics for urinary tract infections. Consensus was reached for more than half of the statements within each setting. Conclusions. Experts from different settings and nationalities acknowledge that multiple misconceptions and knowledge gaps can contribute to inappropriate use of antibiotics in the community. These results provide valuable information to use in educational campaigns for patients and healthcare professionals to improve the use of antibiotics.

Keywords: antimicrobial resistance; antibiotics; antibiotic use; misconceptions and knowledge gaps; general practice; out-of-hours services; nursing homes; community pharmacies

1. Introduction

The rise in antimicrobial resistance (AMR) impacts the effectiveness of antibiotics dramatically [1]; a 2022 systematic analysis [2] estimated 4.95 million deaths globally in 2019 due to AMR of which about 1.27 million were directly attributable to infections caused by resistant bacteria. Inappropriate use of antibiotics, i.e., overprescribing and misuse, is the main driver of AMR [3]. To ensure effectiveness of antibiotics in the future, it is essential to improve rational antibiotic use.

Misconceptions and lack of knowledge about antibiotics are important factors contributing to inappropriate antibiotic use [4]. According to the literature, from the patient perspective, these include false perceptions of use and effectiveness of antibiotics and lack of understanding of AMR. From the perspective of the healthcare professionals (HCPs), a perceived demand of antibiotics by the patients and fear of under-treatment are among the misconceptions that can lead to overprescribing of antibiotics [4].

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To address misconceptions and knowledge gaps, it is crucial to identify these systematically and use this information to develop suitable information materials that can be implemented in antimicrobial stewardship programs. Antimicrobial stewardship programs lead to a sustainable change in the behavior of antibiotic prescribing and consumption [5] when they involve all relevant settings and local stakeholders [6,7]. Therefore, it is important to include the end-users in the design process to increase the applicability and suitability of the intervention materials [8].

Whilst knowledge and perceptions about antibiotic use and AMR have been thoroughly studied, such studies often focus on patients [9,10] or students [11,12] in specific settings or countries, and many assess only basic knowledge about indications and efficacy of antibiotics. There has been limited focus on specific groups of HCPs, such as prescribers [13,14] or pharmacists [15]. Furthermore, we lack insight in knowledge gaps and misconceptions that different HCPs in the community setting in Europe come across during their daily practice.

This study is part of the Health Alliance for Prudent Prescribing and Yield of Antibiotics in a Patient-Centered Perspective (HAPPY PATIENT) project [16] that aims to reduce the misuse of antibiotics in human health by involving HCPs from four healthcare settings (general practice, out-of-hours services (OoHS), nursing homes, and community pharmacies) across five target countries (France, Greece, Lithuania, Poland, Spain). The present study aimed to identify and prioritize misconceptions and knowledge gaps that lead to inappropriate use of antibiotics from the perspective of HCPs working in the aforementioned settings. The information about misconceptions and knowledge gaps was used for the development of setting-specific interventions in the HAPPY PATIENT project.

2. Results

2.1. Literature search

The literature search resulted in 46 statements representing knowledge gaps and misconceptions on antibiotic use. The statements were extracted from a total of 27 publications (Supplementary file S3]. These statements were divided into four domains: 1) AMR in general, 2) use of antibiotics in general, 3) antibiotics for acute respiratory tract infections, and 4) antibiotics for urinary tract infections. After review of the statements by the HAPPY PATIENT project consortium members, a total of 44 final statements were included in the study.

2.2. Delphi process

Altogether, 66 experts completed the first round of the Delphi study, of whom 45 (68%) completed the second round (Table 1).

Healthcare professionals in general practice rated 39 statements to be important or very important with at least 80% consensus, which was higher than in OoHS (26 statements), nursing homes (18 statements) and pharmacies (31 statements). After the expert meeting and the second Delphi round, the number of statements that reached consensus changed in all settings. It decreased in general practice (34 statements) and increased in OoHS (30 statements), nursing homes (24 statements) and pharmacies (36 statements) (Table 2).

Table 1. Overview of participants who completed both Delphi rounds.

	General practice	*Out-of-hours Services*	*Nursing homes*	*Pharmacies*	**Total**
France	2	2	1	2	7
Greece	2	1	0	1	4
Lithuania	3	3	2	3	11
Poland	3	3	3	3	12
Spain	3	3	2	3	11
Total	13	12	8	12	45

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Table 2. Statements that reached 80% consensus for the first and second round. Data are presented separately for the four settings.

	General Practice		Out-of-Hours Services		Nursing Homes		Community Pharmacies	
	Round 1 (N=17)	Round 2 (N=13)	Round 1 (N=16)	Round 2 (N=12)	Round 1 (N=15)	Round 2 (N=8)	Round 1 (N=18)	Round 2 (N=12)
Theme 1: AMR[1] (8)	8	6	8	4	6	6	7	7
Theme 2: Antibiotic use (9)	7	4	8	6	5	5	8	9
Theme 3: RTIs[2] (15)	13	12	8	12	6	5	11	12
Theme 4: UTIs[3] (12)	11	12	2	8	1	8	5	8
Total (44):	39	34	26	30	18	24	31	36

[1]AMR: Antimicrobial resistance [2]RTIs: Respiratory tract infections [3]UTIs: Urinary tract infection.

2.3. Antimicrobial resistance

Four out of eight statements within the theme of AMR reached consensus for importance in all four settings (Table 3), for the other statements there was no consensus in at least two settings. The experts experience that patients do not consider AMR a problem in their country and that not all antibiotics are at risk of becoming ineffective. Regarding HCPs, there is misconception about resistance not being a problem at their own workplaces and that newly discovered antibiotics will solve the problem of resistance.

Table 3. Mean and percentage of consensus for all statements per setting divided by theme.

No	Statements Divided by Theme	Mean	Consensus Level (%)	Mean	Consensus Level (%)	Mean	Consensus Level (%)	Mean	Consensus Level (%)	4-Setting Consensus
	Theme 1: Statements related to antimicrobial resistance in general	General practice		Out-of-hours services		Nursing homes		Community pharmacies		All settings
1	Bacteria resistant to antibiotics are only present in hospitals*	4.46	100.0	3.92	66.6	4.38	75.0	4.46	91.7	
2	Antimicrobial resistance is not a problem in my country*	4.46	84.6	4.46	91.7	4.46	87.5	4.46	91.7	x
3	I cannot contribute to the increase of antimicrobial resistance*	4.38	92.4	4.25	75.0	4.38	87.5	4.38	91.7	
4	Others, not me, are responsible for controlling the problem of antimicrobial resistance†	4.23	92.3	4.00	75.0	4.23	87.5	4.23	91.7	
5	Antimicrobial Resistance is not a problem where I work†	4.15	92.3	4.15	83.3	4.15	100.0	4.15	83.3	x
6	Antimicrobial resistance is not an important problem because better antibiotics are continuously being discovered†	4.08	84.7	4.08	91.7	4.08	100.0	4.08	91.7	x
7	Not all antibiotics are at risk of becoming ineffective against infections by resistant bacteria*	4.00	77.0	4.00	83.3	4.00	62.5	4.00	91.6	x
8	If I am not exposed to antibiotics (e.g. directly by consuming antibiotics, or indirectly via the environment), then I cannot carry or transmit antibiotic-resistant bacteria*	4.00	77.0	4.00	75.0	3.85	87.5	3.67	66.7	
	Theme 2: Statements about the use of antibiotics in general	General practice		Out-of-hours services		Nursing homes		Community pharmacies		All settings
9	It is fine to use leftover antibiotics (or sharing antibiotics with family and friends) without consulting a healthcare professional, when experiencing similar symptoms to previous acute infections*	4.92	100.0	4.92	91.6	4.13	75.0	4.92	100.0	
10	The single presence of fever suggests high probability of bacterial infection and need of antibiotics*	4.46	92.3	4.17	75.0	4.46	87.5	4.46	100.0	
11	The benefits of prescribing antibiotics when unsure of the bacterial or viral origin of the symptoms outweigh the harms of exposure to antibiotics†	4.46	84.6	4.46	100.0	4.46	100.0	4.46	100.0	x
12	Antibiotics are effective against all type of infections*	4.38	84.6	4.38	100.0	4.38	100.0	4.38	100.0	x

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13	Broad spectrum antibiotics, such as quinolones and 3rd - 5th generation cephalosporines, are the best treatment options because they cover a wide range of bacteria†	3.85	69.3	3.85	91.6	3.85	87.5	3.85	83.3	
14	Ending the consultation without an antibiotic prescription, when the patient is asking for it, indicates lack of empathy from the doctor*	3.85	77.0	3.85	91.7	4.13	75.0	3.85	91.7	
15	Ending the consultation without an antibiotic prescription indicates that the doctor is not taking my symptoms seriously enough*	3.77	69.3	4.25	91.7	3.77	100.0	3.77	91.7	
16	Ciprofloxacin, doxycycline, levofloxacin, ofloxacin, tetracycline, trimethoprim do not cause sensitivity to sunlight†	3.23	53.9	3.67	66.7	4.00	75.0	3.23	83.4	
17	A good doctor is the one that prescribes the newest type of antibiotics†	3.15	53.9	3.83	75.0	4.13	75.0	3.15	91.6	
	Theme 3: Statements about the use of antibiotics for respiratory tract infections	General practice		Out-of-hours services		Nursing homes		Community pharmacies		All settings
18	More than 2 weeks coughing suggests a high probability of bacterial infection and need of antibiotics†	4.69	92.3	4.69	100.0	4.00	75.0	4.69	100.0	
19	As soon as I feel symptoms like sore throat, running nose, fever I should seek medical care to get antibiotics*	4.62	92.3	4.62	83.3	4.62	100.0	4.62	91.6	x
20	All children with middle ear inflammation and ear pain require antibiotic therapy†	4.54	92.3	4.54	91.7	3.50	50.0	4.54	100.0	
21	The single presence of tonsillar exudate in patients with sore throat suggests a high probability of bacterial infection and need of antibiotics†	4.46	92.3	4.46	91.6	4.00	75.0	4.46	83.3	
22	In patients with sore throat and other symptoms such as tonsillar exudates, fever, tender anterior cervical adenopathy, antibiotics have a great impact in the course of symptoms by shortening the length of symptoms by more than two days†	4.46	100.0	4.46	91.7	4.46	100.0	4.46	83.4	x
23	Based on the characteristics of the cough the health care professional can differentiate the viral or bacterial origin of the cough. For example, a chesty cough (wet, productive or phlegmy) means that it is caused by a bacterium†	4.38	92.3	4.38	91.7	3.38	62.5	4.38	83.4	
24	A patient with the combination of two or more of the following symptoms : a) nasal congestion, b) nasal discharge, c) pain in the face/teeth, d) reduced sense of	4.31	92.3	4.31	83.3	3.63	62.5	4.31	100.0	

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	smell, e) fever; requires antibiotic therapy independently of the number of days with symptoms†									
25	Cough with purulent sputum (or change of color of the sputum) suggests a high probability of bacterial infection and need of antibiotics†	4.31	84.6	4.31	91.6	4.31	100.0	4.31	100.0	x
26	The single presence of tender anterior cervical adenopathy in patients with sore throat suggests a high probability of bacterial infection and need of antibiotics†	4.23	84.7	4.00	75.0	4.23	87.5	4.17	75.0	
27	Purulent nasal discharge suggests a high probability of bacterial infection and need of antibiotics†	4.23	84.6	4.23	91.7	4.23	87.5	4.23	100.0	x
28	The majority of patients with a sore throat require antibiotic treatment†	4.15	84.7	4.15	83.4	3.63	62.5	4.15	91.7	
29	A bacterial infection is the most common cause of the single or combined presentation of the following symptoms: a) nasal congestion, b) nasal discharge, c) pain in the face/teeth, d) reduced sense of smell, e) fever†	3.92	84.6	4.17	75.0	3.88	75.0	4.50	83.4	
30	The presence of cough without other symptom suggests a high probability of bacterial infection and need of antibiotics†	4.08	77.0	4.08	83.3	3.75	62.5	4.08	91.7	
31	Macrolides are the best first option for treating a bacterial lower respiratory tract infection in order to cover typical and atypical pathogens†	3.85	69.3	3.85	91.6	4.13	75.0	3.83	66.7	
32	A sinus X-Ray can help doctors to discriminate the bacterial or viral origin of the rhinosinusitis symptoms†	3.31	53.9	3.33	58.3	3.50	50.0	3.33	41.6	
	Theme 4: Statements about the use of antibiotics for urinary tract infections	General practice		Out-of-hours services		Nursing homes		Community pharmacies		All settings
33	The single presence of painful discharge of urine suggests a high probability of bacterial infection and need of antibiotics†	4.69	100.0	4.69	83.3	4.69	87.5	4.69	91.6	x
34	The single presence of frequent urination suggests a high probability of bacterial infection and need of antibiotics†	4.54	100.0	4.54	91.7	4.00	75.0	4.54	100.0	
35	The single presence of burning sensation during urination suggests a high probability of bacterial infection and need of antibiotics†	4.54	100.0	4.54	91.7	3.88	75.0	4.54	100.0	
36	The single presence of blood in urine suggests a high probability of bacterial infection and need of antibiotics†	4.46	92.3	4.46	83.3	4.46	87.5	4.46	100.0	x
37	When a patient comes with acute UTI symptoms it is okay to prescribe antibiotics, despite of the negative	4.46	100.0	4.46	100.0	4.46	87.5	3.17	25.0	

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	result of a dipstick test [nitrites (-), leucocytes (-)]. A negative dipstick test is not a good predictor of absence of UTI†									
38	Leucocytes positive and nitrite negative result in a dipstick test indicates with high certainty bacterial infection and need of antibiotics†	4.31	92.3	4.00	75.0	4.31	87.5	3.58	41.7	
39	The single presence of smelly urine suggests a high probability of bacterial infection and need of antibiotics†	4.31	84.7	3.92	75.0	4.00	75.0	4.31	83.4	
40	The single presence of cloudy urine suggests a high probability of bacterial infection and need of antibiotics†	4.31	84.7	3.75	66.7	4.31	87.5	4.31	83.4	
41	A positive dipstick in the elderly without urinary tract symptoms is a strong indicator for urinary tract infection and requires antibiotics†	4.31	92.3	4.31	83.4	4.31	100.0	3.67	50.0	
42	The single presence of persistent urge to urinate suggests a high probability of bacterial infection and need of antibiotics†	4.23	84.7	4.23	83.3	3.75	75.0	4.23	100.0	
43	In an uncomplicated UTI, antibiotic treatment should be started as soon as possible to prevent the dissemination of the infection to the kidneys and bloodstream, independently of the risk of complication†	4.23	84.7	4.23	83.3	4.23	87.5	4.23	91.7	x
44	Cognitive changes (e.g. agitation, confusion) in the elderly suggest a high probability of bacterial infection and the need of antibiotics, even without the presence of urinary tract symptoms†	4.00	84.7	4.08	75.0	4.00	87.5	3.75	58.3	

Notes: The statements from the point of view of the healthcare professional and the patient are marked differently in the table (* From the point of view of the patient, † from the point of view of the healthcare professional). Statements have reached consensus where the consensus level is ≥ 80%.

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2.4. General use of antibiotics

In the four settings, consensus of importance was reached for two of nine statements (Table 3). Across all settings there was consensus that patients believe that antibiotics are effective against all type of infections. Furthermore, there was consensus that HCPs erroneously believe that the benefits of prescribing antibiotics when unsure of the bacterial or viral origin of the symptoms outweigh the harms of exposure to antibiotics. For an additional four statements a consensus of importance was reached in three of the four settings.

2.5. The use of antibiotics for respiratory tract infections

Of the fifteen statements on the use of antibiotics for respiratory tract infections four were deemed important by the experts (Table 3). This included the only statement from the patients' perspective that certain symptoms imply the need for antibiotics. This extends to the statements from the perspective of HCPs, where the misconceptions of sore throat with regional symptoms and fever, cough with purulent sputum or purulent nasal discharge suggest a bacterial infection that require antibiotics, are considered important.

2.6. The use of antibiotics for urinary tract infections

The final statements for which consensus of importance was reached in four settings were three of the twelve statements regarding antibiotic use for urinary tract infections (Table 3). Two of these were similar to statements for respiratory tract infections where there is misconception about the presence of specific symptoms, which would imply the need for antibiotics. The third statement concerns the use of antibiotics to prevent complications of an uncomplicated urinary tract infection.

3. Discussion.

3.1. Main findings

In total, 44 misconceptions were identified through the literature search, eleven targeting patients and 33 targeting HCPs. Healthcare professionals in all settings recognize there are numerous misconceptions or knowledge gaps about AMR, however, the setting in which they act influences which specific misconceptions they rate as important. To a certain extent, this can be explained by the nature of the different settings; in nursing homes, sharing of leftover antibiotics with family or friends is not considered a relevant misconception. Similarly, as pharmacists generally do not use diagnostic tests, diagnostic tests are not rated important in this setting. Generally, the experts reached consensus on a list of misconceptions regarding antibiotics, therewith establishing a fundament for the development of interventions to improve antibiotic use and increase knowledge.

3.2. Strengths and limitations of the study

The main strength of this study is that we used input from a panel of experts who have profound experience within their fields and in antimicrobial stewardship initiatives. Additionally, the sample of experts was interdisciplinary and cross-national. Previous studies have shown that a heterogeneous sample allows for a wider range of perspectives to be taken into consideration, and thus, leading to a better performance and increased quality and acceptance of decision [18,20–22].The rating of the statements was conducted anonymously, thus the discussion and consensus process were not dominated by only a small group of experts [18–20].

This study has several limitations that are inherent to the Delphi methodology or introduced through modifications for the specific aims of this study. Common limitations of the Delphi methodology include the lack of a definition on how to define consensus [23], who qualifies as an expert [18,24] and lack of agreement about the optimal number of rating rounds [18–20,23,25]. Additionally, the size of the Likert scale has been debated in the literature and may come with some

methodological limitations [19,23,24,26]. We used a five-point Likert scale, as it ranks high in terms of reliability, validity, and ease of use.

Lack of English fluency is a limitation of the study, however, our partners in the target countries facilitated the communication with the participants in national languages we reduced the limitation of the language barriers by translating all the statements, instructions, and all study material.

The typical first round of "idea generation" was replaced with a literature search and the study participants received a pre-selected list of statements upon which they were invited to make a judgement. The main advantage of this modification is that the study participants start from a common base, and it allows for an easier data analysis and interpretation [25]. However, this meant that the participants could not introduce new statements, which may have resulted in biased responses [25]. Nevertheless, this type of bias was limited by conducting a broad and structured literature search and discussing the statements with the HAPPY PATIENT consortium.

Finally, the multi-national and multi-disciplinary nature of the study, meant excluding potentially relevant details for specific countries, however, this approach facilitates the creation of educational content based on the results that can be easily transferred to other settings and countries within the EU.

3.3. Comparison with existing literature

A 2015 systematic review [27] on physicians' knowledge, perceptions and behavior towards antibiotic prescribing in ambulatory and hospital settings found that physicians still have inadequate knowledge about AMR and misconceptions about antibiotic prescribing. The review reports that physicians in many studies did not consider AMR to be a problem in their own clinical practice and would prescribe antibiotics despite knowing that they would have limited benefit for the patients. Similarly, other researchers found that HCPs are aware of AMR being a problem in general, but they do not believe it is a problem in their clinical practice [28]; that HCPs prefer to overprescribe antibiotics to avoid clinical failure or when they are in doubt [28–30]; that national antibiotic prescription guidelines have low impact on HCPs prescribing attitudes [28,31]; and that HCPs tend to overprescribe antibiotics to meet patients' expectations [29,32,33] .

In line with other studies that were conducted in various healthcare settings, we found that some common misconceptions that need to be addressed in intervention materials are 1) that HCPs do not believe that AMR is a problem in their own practice and 2) that they often prescribe antibiotics when they are in doubt about the cause of the infection. Additionally, our study pointed out that antibiotics for UTIs are overprescribed especially in the nursing homes, as the HCPs often misinterpret non-specific symptoms for UTI, or may treat asymptomatic bacteriuria more often than not, despite the fact that bacteria in the urinary tract are very common among the elderly [34].

Previous studies exploring knowledge gaps and misconceptions from the patient perspective found that it is a common misconception that antibiotics are effective against viral infections [35–38]; that they are effective against or reduce the duration of symptoms of the flu or the common cold [35–38]; that a cough of duration longer than two weeks requires antibiotic treatment [38]; that it is fine to take antibiotics if they were used in the past to treat similar symptoms [37,38]; and that the public has limited knowledge about AMR and how it occurs [36–40]. Our study affirmed that all the above-mentioned patient misconceptions about antibiotics and AMR are a very common issue that HCPs face in their daily practice and may lead to misuse of antibiotics.

Based on this study, we developed six educational tools (e.g. leaflets, posters, checklists) aimed at HCPs and the public that can be used in the different healthcare settings involved in the study (Supplementary file S4). These tools aim to support the communication between the HCPs and the patients when they discuss their infection and the need and use of antibiotics. The tools contain information about several community-acquired infections, antimicrobial stewardship messages, use of antibiotics, infection prevention messages, and more. Previous antimicrobial stewardship campaigns have created similar educational tools that aim to increase patient knowledge about antibiotics and AMR [41–44]. The authors encourage practicing HCPs and researchers to use the materials and to develop new material based on this study.

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4. Materials and Methods

4.1. Design

The study adopted a modified Delphi technique to reach consensus [17–20]. This Delphi study was modified in the form of an email survey with expert online meetings in between the two rounds, and the typical "idea generation" first round was replaced with a literature search (Figure 1).

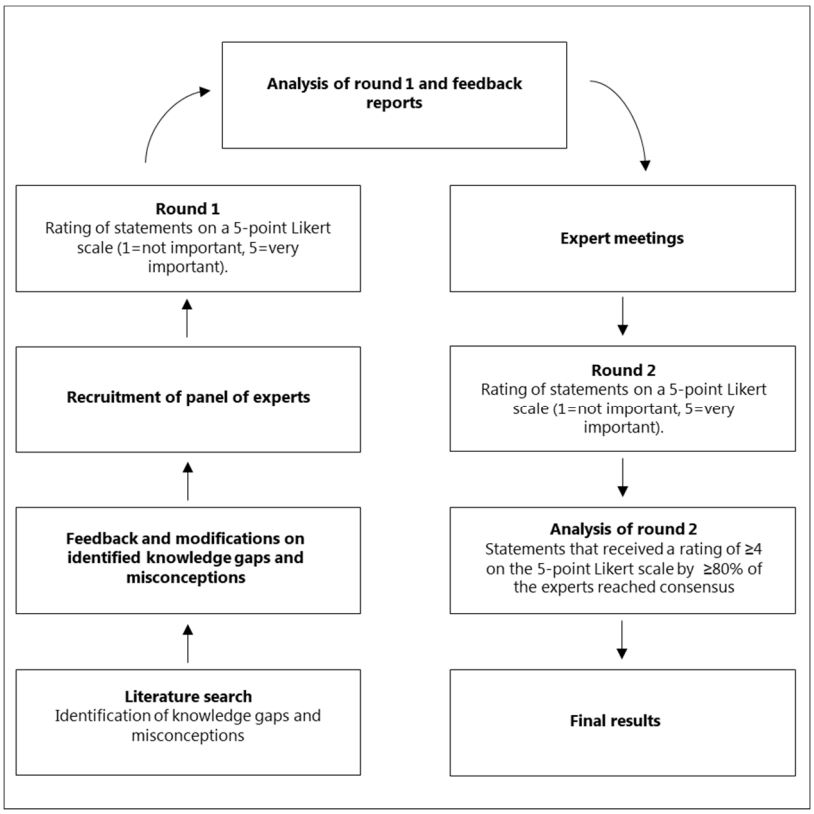

Figure 1. Flow chart of the study process.

4.2. Recruitment and sample size

A panel consisting of experts from the four different settings (general practice, OoHS, nursing homes, and community pharmacies) and the five target countries (France, Greece, Lithuania, Poland, and Spain) was recruited. A member of the HAPPY PATIENT consortium from each country recruited the experts (List of project partners in Supplementary file S1) through national and European professional associations of HCPs, who were then asked to identify other potential experts. We aimed to recruit three experts per county per setting, resulting in 60 experts to complete both rounds of the Delphi process.

Experts were eligible and invited for inclusion if they: a) were HCPs with knowledge and experience within diagnosis of common community-acquired infections, antibiotic use, management of medicines, and antimicrobial stewardship programs; and ii) had no conflicts of interest in participating in the study. There were no restrictions on English fluency, as all materials were translated into national languages.

4.3. Identification of misconceptions and knowledge gaps

We conducted a literature review during May-June 2021 in PubMed, REX library system, and Google Scholar. Search terms included "(antibiotics) AND (misconceptions)", "(antibiotics) AND (knowledge)", "(antimicrobial resistance) AND (misconceptions)", "(antimicrobial resistance) AND (public knowledge)", "(urinary tract infection) AND (misconceptions)", "(respiratory tract infection) AND (misconceptions)", "(respiratory tract infection) AND (diagnosis)", "(urinary tract infection)

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AND (diagnosis)". Studies were included if published in a peer-reviewed scientific journal in English, regardless of publication date, sample size, study design or geographical location. A.C. and G.C. reviewed titles and abstracts to identify knowledge gaps and misconceptions that lead to inappropriate prescribing, dispensing and consumption of antibiotics when managing community-acquired infections, from the perspective of the patient and the HCP. Succeeding the literature review, A.C. and G.C. extracted statements of potential knowledge gaps and misconceptions that may lead to inappropriate use of antibiotics. Subsequently, an iterative review process took place, where the HAPPY PATIENT project consortium reviewed the statements and suggested revisions in the phrasing and in- and exclusion of statements. Emphasis was placed on including statements that were relevant across all target countries.

4.4. Data collection

Two rounds of data collection were implemented between September 2021 and January 2022. SurveyXact® was used to distribute the online survey. A link to each survey was distributed via email to all participants by our host partners, followed by reminders in each survey round.

4.4.1. Round 1

The first round of data collection took place during September-October 2021. The experts received the pre-defined list of 44 statements (Supplementary file S2,) and they were instructed to rate the importance of each statement on a 5-point Likert scale: 1=not important, 2=little important, 3=neutral/I don't know, 4=important, 5=very important. The experts evaluated each statement based on how important they believed the statement contributed to the misuse of antibiotics and the need to be addressed in future intervention materials. The experts were invited to prioritize common misconceptions about AMR, diagnosis and management of community-acquired infections that HCPs face during their daily communication with patients, as well as misconceptions or knowledge gaps of their peers working in their respective healthcare settings that lead to misuse of antibiotics. Response rates were monitored regularly and email reminders were sent to the participants who had not responded to the survey two and four weeks after the initial email invitation.

4.4.2. Feedback and expert meetings

After the first round was completed, all participants received personalized feedback, which included the median, minimal and maximal ratings of each statement. This allowed participants to reflect on their answers based on the group median and provided the basis for the subsequent discussions during the consensus meetings.

During four meetings (one per setting) in November 2021, experts discussed disagreements, provided clarifications, and elaborated on similarities and differences across countries that would benefit the consensus process. During the meetings, no items were discarded from the survey; however, minor changes for some of the statements were suggested and implemented before the second round of the modified Delphi process.

4.4.3. Round 2

The data collection for the second Delphi round took place during December 2021-January 2022. The second survey contained all statements of the first round. In this round, the participants had the opportunity to reassess their initial responses, based on the feedback material and the expert meeting discussions [18,21], and resubmit their rating on the same 5-point Likert scale as in round 1. Response rates were monitored, and email reminders were sent to participants who had not yet completed the survey.

4.5. Definition of consensus and end of Delphi process

Consensus was achieved if ≥80% of the participants rated a statement with 4+ on the five-point Likert scale during the second Delphi round.

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4.6. Data analysis

To identify the most important knowledge gaps/misconceptions for each of the four settings included in the study, the data analysis was conducted per setting. All data was imported and analyzed in IBM SPSS version 27. We ran descriptive statistics and calculated frequencies, median, mean and standard deviation, minimum and maximum ratings for all the statements.

5. Conclusions

Experts from four different settings from five EU countries rated the most important knowledge gaps and misconceptions impacting on inappropriate use of antibiotics for the management of community-acquired infections. The results of this study give an overview of different topics that need to be addressed in educational campaigns to optimize antibiotic use. This study has resulted in the development of different intervention materials and can be used as a guide in the development of future antimicrobial stewardship programs targeting the management of community-acquired infections.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org. Supplementary file S1, Supplementary file S2, Supplementary file S3, Supplementary file S4.

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List of abbreviations:

AMR	Antimicrobial resistance
HCP(s)	Healthcare professional(s)
EU	European Union
HAPPY PATIENT	Health Alliance for Prudent Prescribing and Yield of Antibiotics in a Patient-Centred Perspective
OoHS	Out-of-hours services
RTIs	Respiratory tract infections
UTIs	Urinary tract infections

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